is assigned, and as regards the period, will be found from Ginzel's numbers to be—

|  |  |  |  |  | days |
|---|---|---|---|---|---|
| For Jupiter | ... | ... | ... | ... | – 799·16 |
| Saturn | ... | ... | ... | ... | – 27·27 |
| Uranus | ... | ... | ... | ... | – 7·53 |
| Neptune | ... | ... | ... | ... | – 2·76 |

These figures show a total acceleration of 836·72 days, and hence the most probable epoch of the next perihelion passage is found to be 1886 December 16·9 G.M.T.

After remarks upon the physical observations made in 1815, and Bessel's observation of a nearly central occultation of a star by the comet on April 26, we have extensive sweeping ephemerides to facilitate the rediscovery at the approaching return ; the places are given for every tenth degree of the sun's longitude, and of the true anomaly from – 120° to +120°. In view of the uncertainty in the length of the comet's period, it may be well to commence the search in 1885.

In a supplement Ginzel examines the effect of the attraction of the smaller planets Mercury, Venus, the Earth, and Mars from March 1815 to February 1817 ; also the possible effect of a resisting medium : these are found to be too small to be worthy of consideration practically.

The elements assigned by Ginzel's investigation for the comet's next appearance are :—

Perihelion passage, 1886 December 16·9338 Berlin M.T.

| | | |
|---|---|---|
| Longitude of perihelion ... ... ... | 149 48 40·3 | M. Eq. 1887·0 |
| ,,　　ascending node... ... | 84 31 24·2 | |
| Inclination ... ... .. ... ... | 44 33 34·3 | |
| Angle of eccentricity ... ... ... | 68 31 3·0 | |
| Mean daily sidereal motion ... ... | 49″·387785 | |
| Log. semi-axis major ... ... ... | 1·2375914 | |

To which corresponds a period of revolution of 71·843 years.

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## THE BUILDING OF THE ALPS [1]

### II.

I PASS now to the section of the Simplon. On the southern side, deep in the glen of the Doveria, in the vicinity of the gorge of Gondo, we find a mass of granitoid gneiss, which recalls to mind that already described from the wildest portion of the upper valley of the Reuss. We may, I think, with confidence affirm that, whatever be the true nature of this rock, we are again touching the foundation-stones of the rock masses of the Alps. As we approach Algaby, the granitoid gneiss becomes more distinctly bedded and variable, a thin band of micaceous crystalline limestone is passed, and presently the more rapid ascent of the pass begins. Hence to beyond the summit we traverse, so far as can be seen, a great series of bedded gneisses, often coarse and even porphyritic, and of schists. The same are displayed in the crags of Monte Leone on the east and of the Rossbodenhorn on the west. As shown in Prof. Renevier's valuable section, bands of crystalline dolomitic limestone, and of hornblendic and garnetiferous schists occur in various places on either side of the Simplon road. Then, after descending about half way to Brieg, we strike the group of the Lustrous Schists, with the usual calcareous zone in the lower part. Prof. Renevier does not attempt to unravel the complexities of the strata which compose this portion of the central ridge of the Alps, and I feel that my slighter knowledge makes caution yet more imperative ; but I think we are justified in asserting that we have evidence of an upward succession from the coarse granitoid fundamental gneisses, through more variable and bedded gneisses, to a group which recalls the garnetiferous schists, so finely developed on the southern flanks of the St. Gothard—a group also traceable in the upper portion of the Binnenthal, though apparently far less perfectly developed. I think also that in the gigantic anticlinal of the Simplon we have evidence of sharp flexures on a great scale ; and that these garnetiferous schists are only here and there preserved as the lower ends of infolded loops, so that the bulk of the *massif*, and, so far as I can tell, the actual summit ridges of the Rossbodenhörner and Monte Leone, are composed of the bedded gneisses and strong schists, and perhaps of the more friable gneisses which have been already described in the mountains further to the east.

The mountains further west—the aspiring peaks which rise

around the two branches of the Visp, including among them some of the highest summits of the Alps, such as Monte Rosa, the Mischabelhörner, the Matterhorn, and the Weisshorn—offer indeed magnificent sections, but are full of difficulty. The fundamental gneiss, if I mistake not, is occasionally exposed—as, for example, in the rocks of Auf der Platte, at the base of Monte Rosa ; and in parts of the Mischabelhörner blocks of coarse granitoid rock, often very porphyritic, which I refer to the same series, are brought down by the glaciers. There are also mica schists in plenty, such as the summit rocks of Monte Rosa and the backbone—if the phrase be permitted—of the Mischabel- and Saaser-hörner, which I refer to the second zone already described—that of the bedded gneisses and strong mica schists. I have also seen specimens which closely resemble the garnetiferous schists of the St. Gothard district, but we meet in this district with a group of rocks which, if not altogether unknown before, appear now to be developed to an exceptional extent, and to become an important factor in the Alpine crystalline series.

Those who are familiar with the environs of Saas and Zermatt will remember how frequently schists or schistose rocks of a greenish colour occur. Sometimes they are interbedded with strong mica schists, or schisty quartzites, sometimes they form homogeneous masses of considerable extent. It is possible that some of the latter are intrusive masses of serpentine, to which subsequent pressure has given a schistose aspect ; certainly there are occasional masses of coarse gabbro, which I think undoubtedly an intrusive igneous rock ; but still, making all allowance for such cases, there is in this region a considerable mass of greenish hornblendic, talcose, and serpentinous rocks which appears to be non-igneous in origin. We find these all around Zermatt. They form the ridges of the Gorner Grat and of the Hornli. They break out through the snows of the Breithorn and Little Mont Cervin, and constitute no inconsiderable portion of the mighty obelisk of the Matterhorn. The whole of that peak, according to the investigations of Sgr. Giordano—and with this my own recollections correspond—consists of an apparently regularly bedded series of serpentinous and micaceous schists, and of greenish gneisses, with the exception of a gabbro, developed on the western side, which I have no doubt is an intrusive rock. Can we trust these indications ? Are we justified in assigning to this zone, with those characteristics, a vertical thickness of more than a mile ? To these questions I can give at present no answer, further than to state that I am convinced that, notwithstanding the apparent regularity of the bedding in this and the neighbouring peaks, there are really great folds which patient scrutiny may at length unravel, and that this zone of greenish rocks—for which Alpine geologists have proposed the name of *Pietra Verde* group, appears to underlie the garnetiferous series of silvery mica schists, and either to overlie or replace the upper portions of the banded gneiss series which succeeds to the fundamental series.

I do not propose to weary you further with the details of Alpine sections, except that I must add a few words upon the extent of this remarkable series to which I have now introduced you. On the northern side of the watershed in the Swiss Alps, so far as I am aware, it is not generally strongly developed, except in certain localities in the southernmost of the three ranges which make up the whole chain, but in parts of the Tyrol it is well displayed. It borders—the mica schists sometimes dominating—the fundamental gneiss in the Oetzthal *massif ;* it forms the peak of the Gross Glockner ; it meets us on the Brenner Pass and elsewhere overlain by and folded up with rocks which, if my memory do not mislead me, are the equivalents of the Lustrous Schists of more western districts.

Again, it is finely developed, seemingly in succession to bedded coarser gneiss, in some of the peaks of the Bernina range, and it occupies a considerable tract about the heads of the valleys to the south. It may be traced, indeed, over a great zone, and with but slight interruption all along the southern slopes of the Alps, even to the south of the head waters of the Po, forming many of the grandest peaks in the Graian, Tarentaise, Maurienne, and Cottian Alps ; and we find traces of it overlying the coarse granitoid series in the *massif* of the Alps of Dauphiné.

Sections, indeed, in the neighbourhood of Biella, according to Gastaldi and Sterry Hunt, exhibit the Pietra Verde group overlying the upper or more bedded portion of the great gneissic or basal series, and succeeded by the group of friable gneisses, described above as closely associated with the garnetiferous schists, in a manner that suggests an unconformity. Under ordinary circumstances we should not hesitate to admit

that there is considerable evidence in favour of this break, and some for one between the Pietra Verde group and the stronger gneisses and schists below ; but in mountain regions we fear to trust our eyes. The evidence, however, in certain districts in favour of a break at the base of the Lustrous Schists is yet stronger. If I am right in regarding the Lustrous Schists as forming one group with the older part of the Bundnerschiefer of the Grisons region, and of the Thonschiefer of Von Hauer in the Eastern Alps, a study of the geological map will show that it is difficult to explain the relation of these beds to the underlying gneisses and schists without such an hypothesis. What I have myself seen in regard to the Lustrous Schists is strongly in favour of a great break in some localities. On the south side of the St. Gothard we have in the Val Piora the Lustrous Schists apparently in true succession with the representatives of the garnetiferous group of the Val Tremola, yet on the northern side, in the Urserenthal, the latter series is wanting, and the gneisses which underlie it appear to be immediately succeeded by the Lustrous Schists. This, however, might be explained by a complication of faulting and folding. What I have seen in the Binnenthal is harder to explain. At the head of the Hohsand Glacier, just below the peak of the Ofenhorn, we have a coarse but bedded gneiss, which I should correlate with the series immediately overlying the granitoid gneiss so often mentioned as the lowest rock of all. Glancing towards the north, across the snowfield, we see this rock in the base of the Strahlgrat distinctly overlain by the Lustrous series, with its characteristic band of limestone or dolomite. This series swoops down for some 2000 feet, and we cross it in the upper basin of the valley below, while yet further down the valley I detected the characteristic garnetiferous schist, of which, however, there is no great development. If this be the result of faulting and folding only, it is certainly very remarkable.

But I must linger no longer over details. The passing time warns me that I must attempt briefly to describe the general process of the building of this great mountain group of Europe. I have, I hope, proved that the metamorphic rocks of the Alps, if we may trust mineral similarity and mineral and mhological sequence, are vastly older than the Carboniferous period, and that in this ancient series a certain succession may be made out. If we may reason from the analogy of other regions, we may assign to the whole of their latest group (the Lustrous Schists) an antiquity greater than the earliest rocks in which indisputable traces of organic life have been found. One point, however, I should notice before proceeding further. It might perhaps be said—it has indeed been said—that the crystalline schists and gneisses of the Alps are the result of the great earth movements by which the mountains were upraised, when heat and pressure changed mud into schists and felspathic sandstone into gneiss. I have shown you that we can trace a mineral succession in the crystalline series of the Alpine chain, and that some at least of these are earlier than the Carboniferous period ; but I can add to the proofs that these great rock masses had assumed in the main their present mineral structure when these movements occurred. We meet with some rock masses whose structure is doubtless due to the pressure which they have undergone. This is the case with all cleaved rocks, as was lucidly explained twenty-eight years since by Prof. Tyndall in this very room. We meet also with schists, where, from the arrangement of the mineral constituents, we have good reason for supposing that they were developed when the rock mass was exposed to a pressure definite in direction. Here the lines of different minerals, which we believe indicative of an original structure in the rock, are often wrinkled ; the more flaky minerals commonly lie with their broader planes parallel, but, notwithstanding this, there is no very definite cleavage in the rock mass, nor tendency to separate easily along the different mineral layers. Specimens of such rocks may be obtained in the Alps, but there are others in which the layers have evidently been crumpled up after the period of mineral change : the bands of quartz and felspar have been, as it were, crushed together, the flakes of mica are sometimes crumbled and sometimes twisted round into new positions.

The subject is a technical one, so I must ask you to accept my statement, without the long details of microscopic work on which it is founded, that the older Alpine rocks frequently testify to having undergone an extraordinary amount of crushing. In the middle of coarse gneisses, for example, streaks and thin bands of a mica schist may be found, which are not due to an original difference of materials, but to the fact that here and there the original rock has yielded to enormous pressure, and has been crushed *in situ* into lenticular bands of rock dust, from which some new mineral developments have taken place. You may notice also in some regions, where you would classify the rocks at first sight as mica schists, that a close examination of the broken surfaces at right angles to what appear to be planes of foliation reveals a structure resembling a coarsish gneiss. The microscope shows that the rock is really a gneiss, somewhat crushed, and that the micaceous layers are of extreme tenuity— mere films, which do not seem to have been original constituents. The gneissic mass has been crushed, cleaved, and on the cleavage planes films of a hydro-mica have been developed. We cannot fail to be struck, when once our eyes have been opened to it, by the frequency of a slabby structure in the more central parts of the Alpine ranges, the surfaces of these slabs being coated with minute scales or films of mica. These are really records of a rude cleavage which has been impressed upon the more central and less flexible portions of the Alps during the great earth movements which they have undergone since they were first metamorphosed.

Thus in the building of the Alps our thoughts are carried very far back in the earth's history, far beyond the earliest strata of the Palæozoic age. Under what conditions were these great homogeneous granitoid masses of the fundamental gneisses formed ? They differ on the one hand from granites, on the other from the ordinary gneisses ; from the former their differences are but slight, and of uncertain value, yet into the latter they appear to graduate. There is nothing like to them in any subsequent rock group, and, so far as our knowledge at present goes, they appear to be the records of a period unique in the world's history. This may well be. When the dry land first appeared, when the surface of the earth's crust had not long ceased to glow, when the bulk of the ocean yet floated as a vapour in the heated atmosphere, when many gases now combined were free, we can well imagine that the earliest sediments would be deposited under conditions which have never been reproduced. In the later schists, with their more frequent mineral changes, their distinct stratification, and their beds of quartzite and of limestone, we may mark the gradual approach to a more normal condition of things. Some, such as the Lustrous Schists, may indeed be contemporaneous with our earliest Palæozoic rocks ; but I confess that to myself the evidence appears more favourable to the idea that all are more ancient than the period which we call Cambrian, and that the majority are so I feel little doubt.

Supposing, then, that I am right in considering all the Alpine schists, even the Lustrous group, to be pre-Cambrian, we have a vast interval of time which has left no record in those districts of the Alps of which I have been speaking. It is not till we come to the Carboniferous period that we can identify any pages in the life-history of the earth. We are justified with regard to these in the following conclusions :—

That in the place of the Alps there was at that time an upland district, composed of gneisses and schists, in substantially the same mineral condition as they are at present, together with slaty beds in a comparatively unaltered condition, which district was fringed by a lowland covered by a luxuriant vegetation. Prior to this time, also, the metamorphic rocks of the Alps had been so far folded and denuded that the coarser gneisses were in many places laid bare, and contributed the materials which we now find in such beds as the Val Orsine pudding-stone. Whether there was a pre-Triassic mountain chain occupying some parts of the present Alpine region we cannot venture to say, but I think we may unhesitatingly affirm that there were pre-Triassic highlands.

After the close of the Carboniferous period, and anterior to the middle part of the Trias, there were volcanic outbursts on a large scale in more than one region of the Alps—notably in the district near and to the east of Botzen. After this commenced a period of subsidence and of continuous deposition of sediment. This seems to have begun earlier and to have been at first more rapid in the eastern than in the western area. Since in the former the Triassic beds are generally much thicker and more calcareous than in the latter, one is tempted to imagine that the eastern area quickly became a coraliferous sea, with an occasional atoll or volcanic island. Henceforward to the later part of the Eocene the record is generally one of subsidence and of deposit of sediment. Pebble beds are rare : the strata are grits, shales (or slates), and limestones. Whence the inorganic constituents of these were derived I cannot at present venture to suggest, but though conglomerates are rare, there are occasional indications that land was not very distant. In the eastern Alps, however,

the position of some of the Cretaceous deposits and the marked mineral differences between these and the Jurassic seem to indicate disturbances during some part of the Neocomian, but I am not aware of any marked trace of these over the central and western areas. The mountain-making of the existing Alps dates from the later part of the Eocene. Beds of about the age of our Bracklesham series now cap such summits as the Diablerets, or help to form the mountain masses near the Tödi, rising in the Bifertenstock to a height of 11,300 feet above the sea. Still there are signs that the sea was then shallowing and the epoch of earth movements commencing. The Eocene deposits of Switzerland include terrestrial and fluviatile as well as marine remains. Beds of conglomerate occur, and even erratics of a granite from an unknown locality, of such a size as to suggest the aid of ice for their transport. For the present I prefer, for sake of simplicity, to speak of the upraising of the Alps as though it were the result of a few acts of compression, though I am by no means sure that this is the case. Thus speaking we find that in Miocene times a great mountain chain existed which covered nearly the same ground as the present Alpine region of Mesozoic and crystalline rocks. To the north, and probably to the south, lay shallow seas, between which and the gates of the hills was a level tract traversed by rivers, perhaps in part occupied by lakes. Over this zone, as it slowly subsided—in correspondence, probably, with the uplifting of the mountain land—were deposited the pebble beds of the nagelflue and the sandstones of the molasse.

Then came another contraction of the earth's crust; the solid mountain core was no doubt compressed, uplifted, and thrust over newer beds, but the region of the softer border land, at any rate on the north, was apparently more affected, and the sub alpine district of Switzerland was the result. I may here call your attention to the fact that, whether as a consequence of this or of subsequent movements, the Miocene beds occur on the northern flank of the Alps at a much greater height above the sea than on the southern, and have been much more upraised in the central than in the western and eastern Alps. Further, between the Lago Maggiore and the south of Saluzzo, Mesozoic rocks are almost absent from the southern flank of the Alps, and the Miocene beds are but slightly exposed and occupy a comparatively lowland country. I think it therefore probable that the second set of movements produced more effect on the German than on the Italian side of the Alps, producing on the latter a relative depression. In support of this we may remark that the rivers which flow from the Alps towards the north or the west, start, as a rule, very far back, so that the watershed of the Alps is the crest of the third range reckoning from the north, and the great flat basin of the Po is the receptacle for a series of comparatively short mountain rivers. These also take a fairly straight course to the gates of the hills, while the others change not seldom from the lines of outcrop to the lines of dip of the strata—a fact I think not without significance. To this rule the valley of the Adige in the eastern region is an exception. May not this be due to the remarkable series of minor flexures indicated by the strike of the rocks (Mesozoic and earlier) immediately to the west of it, which probably influences the course of the Adda, and can, I think, be traced at intervals along the chain as far as Dauphiné? Be this as it may, it is obvious that the generally uniform east-north-east to west-south-west strike of the rocks which compass the Alpine chain is materially modified as we proceed south of the Lake of Geneva, changing rapidly in the neighbourhood of Grenoble from a strike north-east to south-west, to one from north-west to south-east. This subject, however, is too complicated to be followed further on the present occasion. I will only add that the singular trough-like upland valleys forming the upper parts of some of the best-known road passes—as, for instance, the Maloya—which descend so gently to the north, and are cut off so abruptly on the south, seem to me most readily explained as the remnants of a comparatively disused drainage system of the Alps.

It remains only to say a few words on the post-Tertiary history of the Alps. We enter here upon a troubled sea of controversy, upon which more than the time during which I have spoken might easily be spent; so you will perhaps allow me to conclude with a simple expression of my own opinion, without entering into the arguments. That the glaciers of the Alps were once vastly greater than at the present time is beyond all dispute; they covered the fertile lowlands of Switzerland, they welled up against the flanks of the Jura above Neufchatel, they crept over the orange gardens of Sirmio, and projected into the plains of Piedmont. By their means great piles of broken rock must have been transported into the lowlands; but did they greatly modify the peaks, deepen the valleys, or excavate the lake basins? My reply would be, "To no very material extent." I regard the glacier as the file rather than as the chisel of nature. The Alpine lakes appear to be more easily explained—as the Dead Sea can only be explained—as the result of subsidence along zones roughly parallel with the Alpine ranges, athwart the general directions of valleys which already existed and had been in the main completed in pre-Glacial times. To produce these lake basins we should require earth movements on no greater scale than have taken place in our own country since the furthermost extension of the ice-fields. This opinion as to the origin of the lakes is, I believe, generally held to be a heresy, but it is a heresy which has been ingrained in me by some twenty years of study of the physiography of the Alps.

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## RECENT MORPHOLOGICAL SPECULATIONS

### I.—*On Alternation of Generations*

IT is more than sixty years since Chamisso pointed out that in Salpa a solitary asexual individual produced a chain of sexual individuals by budding, the viviparous eggs in these becoming in turn the solitary form. This he made his type of *Alternation of Generations*.

Since his time the definition of this peculiar method of reproduction has been narrowed, and the alternation of a series of individuals developed from an unfertilised egg, *i.e.* parthenogenetically, and one or more generations of sexually produced young is now called *heterogamy;* the term *metagenesis* has been invented for cases of alternation of sexual and gemmiparous generations.

Few instances can be cited where the study of a single genus has brought out so many points of interest as in the case of the pelagic Ascidian, Salpa. Two points in the history of this animal still involved in controversy are the first phenomena of embryonic development, and the mutual relationship of the two forms, the solitary individual and the colony that swim united in a chain.

As regards the former matter, the fate of the egg and the origin of the nutritive structure known as the placenta present great difficulties.

While W. K. Brooks (*Bull. of Museum of Comp. Zool.,* Harvard University, iii.) believed that the egg undergoes a regular segmentation resulting in the formation of a gastrula, the cavity of which is divided by a transverse constriction into two chambers, one becoming the "placenta," Todaro (*Atti della R. Accad. dei Lincei,* Rome, 1875, 1880), on the other hand, stated that the solitary Salpa is the result, not of the division of the true ovum, but of the *follicular cells* inclosing it, and that during development, which takes place in a special part of the oviduct, the so-called uterus, a fold of the uterine wall forms a decidua reflexa comparable to that of mammals.

Salensky (*Zool. Anzeiger,* 1881; *Mittheil. d. zool. Stat. zu Neapel,* Bd. iv.) accounts for some of these conflicting statements by showing that great variety exists in nearly allied species, but he also declares that previous observations were often inaccurate. He states that the fertilised ovum divides but slowly, and only till the number of its segments reaches sixteen; and that probably it then entirely disappears, the tissues of the embryo being formed from a varying number of *follicular cells.* In some cases, as *S. bicaudata,* the so-called "decidua" is not represented. To this most exceptional method of development he gives the name of "follicular budding."

Now the theory that Salpa is an instance of the alternation of sexual and gemmiparous generations (*i.e.* of *metagenesis*), which was put forward by Chamisso and supported by the researches of Krohn, has been attacked by Brooks, who believes that the solitary Salpa (which he calls the *nurse*) is hermaphrodite, and gives rise by budding to a chain of males into each of which an egg migrates from the nurse. This view of course supposes that the solitary and chain forms belong to the same generation, they being, in fact, respectively the sexually and asexually produced offspring of one and the same solitary hermaphrodite Salpa. Todaro, on the other hand, states that, in the solitary adult, certain of the follicular cells surrounding the ovum give rise to no organs, but remain as cell-masses; and that from these the stolon is eventually developed. Hence the chain-Salpæ are developed parthenogenetically, and the nurse is an older sexless form, serving to nourish the sexually complete chain.